

## SPECIFICATION

PACKET TRANSFER CONTROL METHOD AND PACKET TRANSFER CONTROL  
CIRCUIT

5

## TECHNICAL FIELD

The present invention relates to a packet transfer control method and a packet transfer control circuit for controlling output order of packets when a plurality of provided packets are selectively output to the output line, and particularly to a packet transfer control method and a packet transfer control circuit according to band control method for performing band guarantee for each flow.

## 15 BACKGROUND ART

In recent years, ADSL (Asymmetric Digital Subscriber Line) and FTTH (Fiber To The Home) have become popular. Therefore, always-on connections service in the consumer market has been popularized, and broadbandalization of access networks has become accelerated. Further, along with development of consumer electronics (home information appliances) corresponding to computerization and popularization of digital image delivery service, it is expected that differentiation demand for communication quality corresponding to various communication services

would be increased.

Currently, in networks such as Internet, best effort service, which does not guarantee communication quality prevails. Along with increase of traffic and appearance of  
5 services to require different communication qualities, deterioration of communication quality for users has become a problem. Therefore, it is thinkable that in the future, realizing high quality QoS (Quality of Service) control in recognition of service types and band demand for every user  
10 flow would be important.

Further, in the future access network, it will be necessary that communication lines with high speed such as 100 Mbps to 1 Gbps at the maximum are massively accommodated in view of cost cutting of the communication system.  
15 Moreover, when many flows are dealt in the high-speed communication line as above, if QoS control is made by scheduling having a queue for every flow such as WRR (Weighted Round Robin), it becomes difficult to obtain scalability for both hardware quantity and scheduler process load.

20 Further, in the after-mentioned patent document 1, a band controller for making band control for every user flow by a simple hardware configuration and a method thereof are disclosed. In the technique disclosed in the patent document 1, first, a traffic flow rate for each flow is  
25 measured in a rate measurement section, the measured input

rate is stored in the flow information storage section, meanwhile a queue length of a buffer for outputting receive packets of each flow to the output line is observed in a queue length monitoring section. Then, from the observed queue  
5 length and the minimum guaranteed band of each flow stored in the flow information storage section, an allowed rate for each flow is calculated in an allowed rate calculation section. Next, the measured input rate and the calculated allowed rate are compared in a disposition control section.  
10 When the input rate is equal to or less than the allowed rate, the packet of the flow is input to the buffer. Meanwhile, when the input rate outreaches the allowed rate, only the outreaching portion is disposed, and thereby control is made so that the input rate of each flow to the buffer can be always  
15 equal to or less than the allowed rate.

According to this technique, control and management are made so that a plurality of flows to be accommodated share one FIFO (First In First Out) buffer. Therefore, even if the number of flows is increased, small-sized hardware  
20 quantity is enough. Further, by monitoring the input rate for every flow and disposing the packet with the input rate equal to or more than the allowed rate, effects of the flow committing band violation (flow with the input rate, which overreaches the allowed rate) on other flows are prevented.  
25 As above, by using the technique disclosed in the patent

document 1, band guarantee for a plurality of flows by a single queue becomes possible. Further, when excess band is generated, the allowed rate for each flow is increased in proportion to the minimum guaranteed band for each flow, and thereby the excess band can be allocated to flows according to the minimum guaranteed band for each flow. Patent document 1: Japanese Patent Laid-Open Publication No. 2002-185459 (paragraphs 0014 to 0021 and 0024, and FIGS 1 and 5)

10           The band controller disclosed in the patent document 1 makes band control by storing all flows in one queue. However, in each flow input to the band controller, various types of packets are mixed. For example, in each flow, packets of different applications are mixed. These packets include various types from a packet, which is relatively tolerant about delay or delay distortion such as E-mail and Web access, a packet requiring real time characteristics sensitive to delay or delay distortion such as audio communications and image delivery, to a packet, which is mission critical involved in backbone operations. As above, when all the flows, in which various types of packets are mixed are stored and controlled in one queue, performing QoS guarantee according to communication quality required for each of various types pf packets in each flow is not possible.

25           Further, the band controller disclosed in the patent

document 1 allocates the excess band in proportion to the minimum guaranteed band of each flow. However, some users allow small minimum guaranteed band, but demands a large region of sending to the excess band, a so-called best effort.

5 It is not possible to satisfy such a demand only by allocating the excess band in proportion to the minimum guaranteed band.

#### DISCLOSURE OF THE INVENTION

In view of the foregoing problems, it is an object of the invention to provide a packet transfer control method and a packet transfer control circuit capable of performing band control for every flow and at the same time realizing priority control by a simple hardware configuration.

10 Further, it is another object of the invention to provide a packet transfer control method and a packet transfer control circuit having high setting freedom capable of quantitatively setting the minimum guaranteed band and the upper limit band for each flow. Further, it is still another object of the invention to provide a packet transfer control

15 method and a packet transfer control circuit capable of, for example, managing a plurality of flows belonging to the same link or the same VPN (Virtual Private Network) as one group to make band control and priority control for each group, in addition to band control and priority control for each

20 flow.

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In order to attain the foregoing objects, in the packet transfer control method of the invention, a flow, to which a provided packet belongs is identified; flow setting information for the identified flow is read out from  
5 previously set information; an arrival rate of the packet is measured; an arrival rate for the flow, to which the packet belongs is calculated based on the arrival rate of the packet; class setting of the flow, to which the packet belongs is performed in units of packet by comparing the arrival rate  
10 for the flow to the read flow setting information; and the output order of the plurality of packets is controlled based on the class of the class-set flow, to which the packet belongs.

Thereby, band control and priority control of packet  
15 output, in which class setting of each flow is performed according to the band that each flow uses, and packets belonging to each flow are output based on this set class can be realized by a simple hardware configuration.

Further, in the packet transfer control method  
20 according to the invention, in the step of performing class setting, when the arrival rate for the flow, to which the packet belongs is less than or equal to a value of the minimum guaranteed band information in the flow setting information, the class of the flow, to which the packet belongs is set  
25 to the reference priority class in the flow setting

information; and when the arrival rate for the flow, to which the packet belongs is larger than the value of the minimum guaranteed band information and is less than or equal to a value of the upper limit band information in the flow setting information, the class of the flow, to which the packet belongs is set to the class lower than the reference priority class in the flow setting information.

Thereby, the class set when the arrival rate for the flow, to which the packet belongs reaches the minimum guaranteed band can be lower than the class set when the arrival rate for the flow, to which the packet belongs does not reach the minimum guaranteed band. Further, excess band can be allocated to a plurality of flows without affecting the flow, which does not reach the minimum guaranteed band.

Further, in the packet transfer control method of the invention, in the step of performing class setting, when the arrival rate for the flow, to which the packet belongs is larger than the value of the upper limit band information in the flow setting information, the class of the flow, to which the packet belongs is set to the class still lower than the class set when the arrival rate for the flow, to which the packet belongs is larger than the value of the minimum guaranteed band information and is less than or equal to the value of the upper limit band information in the flow setting information.

Thereby, the class set when the arrival rate for the flow, to which the packet belongs reaches the upper limit band can be lower than the class set when the arrival rate for the flow, to which the packet belongs does not reach the upper limit band, and other flows can be output by priority. The flow using up excess band is allowed to be output only when there are no other flows of upper priority classes.

Further, in the packet transfer control method of the invention, disposition process of the packet is performed when the arrival rate for the flow, to which the packet belongs is compared to the value of the upper limit band information in the flow setting information, and then the arrival rate for the flow, to which the packet belongs is larger than the value of the upper limit band information in the flow setting information.

Thereby, the packet belonging to the flow, which uses up excess band and outreaches the upper limit band can be disposed, and other flows can be output by priority.

Further, in the packet transfer control method of the invention, order management is performed so that the firstly arrived packet is output first in terms of a plurality of packets belonging to the same flow.

Thereby, management is enabled so that order of packets is maintained and packets are accurately processed at the destination thereof.



Further, in the packet transfer control method of the invention, in the step for controlling output order, flow identification information for identifying the flow is stored in a FIFO queue set correspondingly to each class based  
5 on the class of the class-set flow, to which the packet belongs, and the flow to be output next is specified by reading out the flow identification information from the FIFO queue of the high priority class.

Thereby, class setting can be performed by using the  
10 flow identification information for identifying each flow, and the packet belonging to the flow to be output next can be selected.

Further, in the packet transfer control method of the invention, group setting information for a group, to which  
15 the identified flow belongs is read out from previously set information; an arrival rate for the group, to which the flow belongs is calculated based on the arrival rate of the packet; disposition process of the packet is performed when the arrival rate for the group is compared to a value of the upper  
20 limit band information in the group setting information, and the arrival rate for the group of the flow is larger than the value of the upper limit band information in the group setting information.

Thereby, in addition to band control and priority  
25 control in units of flow, band control in units of group

composed of a plurality of flows can be performed. For example, band control can be performed in units of the same link, the same VPN (Virtual Private Network) or the like, to which a plurality of flows belong.

5           Further, in order to attain the foregoing objects, the packet transfer control circuit of the invention includes a flow identification means for identifying a flow, to which a provided packet belongs; a flow setting information storage means for storing information previously set for  
10 each of a plurality of flows; a rate measurement means for measuring an arrival rate of the packet; a rate calculation means for calculating an arrival rate for the flow, to which the packet belongs based on the arrival rate of the packet; a class setting means for performing class setting of the  
15 flow, to which the packet belongs in units of packet by comparing the arrival rate for the flow to flow setting information for the flow read out from the flow setting information storage means after identification of the flow by the flow identification means; and an output control means  
20 for controlling the output order of the plurality of packets based on the class of the flow, to which the packet belongs set by the class setting means.

          Thereby, band control and priority control of packet output, in which class setting for each flow is performed  
25 according to the band that each flow uses, and packets

belonging to each flow are output based on this set class can be realized by a simple hardware configuration.

Further, in the packet transfer control circuit of the invention, when the arrival rate for the flow, to which the packet belongs is less than or equal to a value of the minimum guaranteed band information in the flow setting information, the class setting means sets the class of the flow, to which the packet belongs to the reference priority class in the flow setting information; and when the arrival rate for the flow, to which the packet belongs is larger than the value of the minimum guaranteed band information in the flow setting information and is less than or equal to a value of the upper limit band information, the class setting means sets the class of the flow, to which the packet belongs to the class lower than the reference priority class in the flow setting information.

Thereby, the class, in which the arrival rate for the flow, to which the packet belongs reaches the minimum guaranteed band can be set lower than the class, in which the arrival rate for the flow, to which the packet belongs does not reach the minimum guaranteed band. Further, excess band can be allocated to a plurality of flows without affecting the flow, which does not reach the minimum guaranteed band.

Further, in the packet transfer control circuit of the

invention, when the arrival rate for the flow, to which the packet belongs is larger than the value of the upper limit band information in the flow setting information, the class setting means sets the class of the flow, to which the packet  
5 belongs to a class still lower than the class set when the arrival rate for the flow, to which the packet belongs is larger than the value of the minimum guaranteed band information and is less than or equal to the value of the upper limit band information in the flow setting  
10 information.

Thereby, the class set when the arrival rate for the flow, to which the packet belongs reaches the upper limit band can be lower than the class set when the arrival rate for the flow, to which the packet belongs does not reach the  
15 upper limit band. The flow using up excess band is allowed to be output only when there are no other flows of upper priority classes.

Further, in the packet transfer control circuit of the invention includes a packet disposition means for performing  
20 disposition process of the packet, when the arrival rate for the flow, to which the packet belongs is compared to the value of the upper limit band information in the flow setting information, and then the arrival rate for the flow, to which the packet belongs is larger than the value of the upper limit  
25 band information in the flow setting information.

Thereby, the packet belonging to the flow, which uses up excess band and outreaches the upper limit band can be disposed, and other flows can be output by priority.

Further, in the packet transfer control circuit of the  
5 invention, order management is performed so that the firstly arrived packet is output first in terms of a plurality of packets belonging to the same flow.

Thereby, management is enabled so that order of packets is maintained and packets are accurately processed at the  
10 destination thereof.

Further, in the packet transfer control circuit of the invention, the output control means has a plurality of FIFO queues set correspondingly to each class and a flow selection means for reading out the flow identification information  
15 from the FIFO queue of the high priority class in order to specify the flow to be output next. The flow identification information for identifying the flow is stored in one of the plurality of FIFO queues set correspondingly to each class based on the class of the class-set flow, to which the packet  
20 belongs, and the flow to be output next is specified by reading out the flow identification information stored in the FIFO queue of the high priority class by the flow selection means.

Thereby, class setting can be performed by using the  
25 flow identification information for identifying each flow,

and the packet belonging to the flow to be output next can be selected.

Further, the packet transfer control circuit of the invention includes a group setting information storage means  
5 for storing information previously set for each of a plurality of groups, in which a plurality of flows are grouped; a group rate calculation means for calculating an arrival rate for the group, to which the flow belongs based on the arrival rate of the packet; and a packet disposition  
10 means for performing disposition process of the packet when the arrival rate for the group is compared to a value of the upper limit band information in the group setting information read out from the group setting information storage means after identification of the flow by the flow  
15 identification means, and the arrival rate for the group, to which the flow belongs is larger than the value of the upper limit band information in the group setting information.

Thereby, in addition to band control and priority  
20 control in units of flow, band control in units of group composed of a plurality of flows can be performed. For example, band control can be performed in units of the same link, the same VPN (Virtual Private Network) or the like, to which a plurality of flows belong.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram for showing a construction example of a packet transfer controller in a first embodiment of the invention;

5        FIG. 2 is a view showing a model of an example of flow setting information stored in a flow setting information storage section according to the invention;

FIG. 3 is a flowchart for explaining an example of operations in a polishing section according to the first  
10        embodiment of the invention;

FIG. 4 is a flowchart for explaining an example of operations in an output queue section according to the invention;

FIG. 5 is a block diagram showing a construction  
15        example of a packet transfer controller in a second embodiment of the invention;

FIG. 6 is a view showing a model of an example of flow/group correspondence information stored in a group setting information storage section according to the second  
20        embodiment of the invention;

FIG. 7 is a view showing a model of an example of group setting information stored in the group setting information storage section according to the second embodiment of the invention and;

25        FIG. 8 is a flowchart for explaining an example of

operations in a polishing section according to the second embodiment of the invention.

#### BEST MODE FOR CARRYING OUT THE INVENTION

5           Descriptions will be hereinafter given of embodiments of a packet transfer control method and a packet transfer control circuit of the invention with reference to the drawings.

<First embodiment>

10           First, a first embodiment of the packet transfer control method and the packet transfer control circuit of the invention will be described. FIG. 1 is a block diagram showing a construction example of a packet transfer controller in the first embodiment of the invention. The  
15 packet transfer controller shown in FIG. 1 includes a flow identification section 1, a flow setting information storage section 2, a polishing section 3, and an output queue section 4. In FIG. 1, flow of packet is indicated by heavy lines, and flow of other information is indicated by thin lines.

20           The flow identification section 1 is provided with a packet sent from, for example, a communication terminal accommodated in a given communication network. The flow identification section 1 refers to header information of the provided packet (input packet), identifies the flow, to  
25 which the input packet belongs, and notifies information for



the result of flow identification(flow identification information) to the flow setting information storage section 2. Types of flows to be identified can be voluntarily set according to needs, for example, classification by different applications, and classification by a sender address, a receiver address, or an intermediary address.

Further, the flow setting information storage section 2 stores information for each flow (flow setting information). The flow setting information storage section 2 sends flow setting information for the flow specified by the flow identification information notified by the flow identification section 1 to the polishing section 3.

FIG. 2 is a view showing a model of an example of the flow setting information stored in the flow setting information storage section according to the invention. The flow setting information shown in FIG. 2 has minimum guaranteed band information (in some cases, hereinafter simply referred to as MPR: Minimum Packet Rate) MPR1 to MPRn; upper limit band information (in some cases, hereinafter simply referred to as PPR : Peak Packet Rate) PPR1 to PPRn; reference priority class information (in some cases, hereinafter simply referred to as ICL: Initial Class) ICL1 to ICLn, to which a flow belongs when each packet arrival rate of each flow is equal to or less than the minimum guaranteed band MPR information; and packet arrival rate

information (in some cases, hereinafter simply referred to as PAR: Packet Arrival Rate) PAR<sub>1</sub> to PAR<sub>n</sub> of respective flows 1 to n (n is an integer number of 1 or more, and the number of flow types to be identified).

5           Of the flow setting information, regarding entries of the minimum guaranteed band information MPR, the upper limit band information PPR, and the reference priority class information ICL, the setting values for respective flows are previously stored. As described later, these entries are  
10   used for packet disposition process, packet class setting process and the like in the polishing section 3. An entry of the packet arrival rate information PAR, as described later, is used for packet disposition process, packet class setting process and the like in the polishing section 3.  
15   Regarding the entry of the packet arrival rate information PAR, the stored value is sequentially updated according to results of packet input monitoring by the polishing section 3.

          The polishing section 3 receives notification of the  
20   flow setting information from the flow setting information storage section 2, is provided with the packet through the flow identification section 1, and performs packet disposition process, packet class setting process and the like. This polishing section 3 has a rate measurement  
25   section 31, a rate calculation section 32, a band comparative

determination section (class setting section) 33, and a packet disposition section 34.

The rate measurement section 31 measures the arrival rate of the packet provided through the flow identification section 1. The rate calculation section 32 calculates the packet arrival rate information PAR for the flow, to which the packet targeted for measurement in the rate measurement section 31 belongs. The band comparative determination section 33 compares the packet arrival rate information PAR, which is calculated in the rate calculation section 32 to the minimum guaranteed band information MPR and the upper limit band information PPR in the notified flow setting information. According to the comparative result, the band comparative determination section 33 outputs disposition request information for instructing disposition of the packet or class setting information for instructing the class, to which the packet belongs. Further, the packet disposition section 34 performs packet disposition process when receiving the disposition request information from the band comparative determination section 33.

Next, descriptions will be given of operations of the polishing section 3 with reference to FIG. 3. FIG. 3 is a flowchart for describing an example of operations in the polishing section according to the first embodiment of the invention. For example, when a packet of a flow *i* arrives

at the polishing section 3, the rate measurement section 31 measures the arrival rate of the packet (Step S301). The measured arrival rate of the packet is notified from the rate measurement section 31 to the rate calculation section 32.

5           Further, the rate calculation section 32 obtains the flow setting information for the flow  $i$ , to which the packet belongs from the flow setting information storage section 2 (Step S302). In this embodiment, the aspect that the flow setting information storage section 2 notifies the flow  
10   setting information identified by the flow identification information to the polishing section 3 is adopted. However, for example, it is possible to adopt an aspect that the flow identification information is notified from the flow identification section 1 to the polishing section 3, and then  
15   the polishing section 3 reads out the flow setting information identified by the flow identification information.

          The rate calculation section 32 newly calculates a packet arrival rate information  $PAR_i$  of the flow  $i$  based on  
20   the measurement result of the rate measurement section 31 and the packet arrival rate information  $PAR_i$  in the flow setting information (Step S303). As a calculation method for the packet arrival rate information  $PAR_i$ , by way of example, a method that counting provided data amount of the  
25   packet belonging to the flow  $i$  is started at a given reference

timing, provided data amounts of packets belonging to the same flow  $i$  are added, and thereby the data amount of the flow  $i$  provided to the polishing section 3 on and after the given reference timing is calculated, and at the next given  
 5 reference timing, the count value is reset can be cited.

That is, by adding the measurement result of the rate measurement section 31 and the  $PAR_i$  in the flow setting information, it becomes possible to calculate the data amount of the flow  $i$  at intervals of a given reference timing.  
 10 As described later (Step S309), the calculation result calculated in the rate calculation section 32 ( $PAR$ ) is stored in the flow setting information, and referred in next calculation of the data amount of the flow  $i$ .

Next, the band comparative determination section 33  
 15 compares  $PAR_i$  calculated in the rate calculation section 32 to the minimum guaranteed band information  $MPR_i$  and the upper limit band information  $PPR_i$  in the flow setting information (Steps S304 and S305). For example, validation is made whether  $PAR_i$  belongs to the following (1)  $PAR_i \leq MPR_i$ , (2)  
 20  $MPR_i < PAR_i \leq PPR_i$ , or (3)  $PAR_i < PPR_i$ .

(1) In the case of  $PAR_i \leq MPR_i$  (in the case of "YES" in Step S304)

The arrived packet is regarded as being within the minimum guaranteed band information  $MPR_i$  set for the flow  
 25  $i$  (that is, the flow  $i$  has not reached the minimum guaranteed

band yet). The packet is set to a class ICLi previously set for the flow i (Step S 306). Further, the band comparative determination section 33 outputs information showing that the packet is set to the class ICLi to the output queue section  
 5 4 as class setting information.

(2)  $MPRi < PARi \leq PPRi$  (in the case of "YES" in Step S305)

It is regarded that the arrived packet satisfies the minimum guaranteed band information MPRi set for the flow i, and uses excess band under the upper limit band information  
 10 PPRi (that is, the flow i has reached the minimum guaranteed band, but has not reached the upper limit band yet). The packet is set to the class one grade lower than the class ICLi previously set for the flow i (Step S307). Further, the band comparative determination section 33 outputs  
 15 information showing that the packet is set to the class one grade lower than the class ICLi to the output queue section 4 as class setting information.

(3)  $PARi > PPRi$  (in the case of "NO" in Step S305)

Regarding the arrived packet, it is regarded that the  
 20 upper limit band PPRi set for the flow i is outreached and all the allowed excess band is used up. The relevant packet is provided with disposition process (Step S308). In this case, the band comparative determination section 33 notifies disposition request information for requesting disposition  
 25 process of the packet to the packet disposition section 34.

The packet disposition section 34 receiving the disposition request information performs disposition process of the packet.

However, for the purpose of effective use of the output  
 5 link band, it is possible to allow the packet to be output if there is still excess band even after the upper limit band is outreached. In this case, the packet is set to the class two grade lower than the class ICLi previously set for the flow i (Step S308). Further, the band comparative  
 10 determination section 33 outputs information showing that the packet is set to the class two grade lower than the class ICLi to the output queue section 4 as class setting information.

Further, when the packet is determined as (1)  
 15  $PAR_i \leq MPRI$  or (2)  $MPRI < PAR_i \leq PPR_i$ , the band comparative determination section 33 updates the packet rate information  $PAR_i$  in the flow setting information for the flow i stored in the flow setting information storage section 2 by new packet rate information  $PAR_i$  ( $PAR_i$  calculated in the rate  
 20 calculation section 32) (Step S309). In this embodiment, when the excess band is used up as in (3)  $PAR_i > PPR_i$ , the packet rate information  $PAR_i$  is not updated. However, even if determination is made as (3)  $PAR_i > PPR_i$ , it is possible to update the packet rate information  $PAR_i$ .

25 As described above, in the polishing section 3, packet

disposition process or class setting process is performed. When class setting process is performed, the packet and the class setting information for the packet are provided from the polishing section 3 to the output queue section 4. In  
5 the class setting information, at least flow identification information enabling identifying the flow for the packet and information showing the class set for the flow related to the packet are described.

Next, descriptions will be given of the output queue  
10 section 4. The output queue section 4 has a buffer section 41, a schedule storage section 42, a flow selection section 43, and a packet output section 44. The buffer section 41 actually stores packets, and controls output order of packets belonging to the same flow. That is, the buffer  
15 section 41 sets, for example, a FIFO (First In First Out) buffer for each flow so that a firstly arrived packet can be output first in terms of the packets belonging to the same flow.

Further, the schedule storage section 42 manages  
20 output order of flows by class according to class setting information provided from the polishing section 3. Further, the flow selection section 43 refers to the output order of flows managed in the schedule storage section 42, selects the flow queued at the head of the highest class, and  
25 instructs the packet output section 44 to output the packet



of the flow. Further, the packet output section 44 reads out from the buffer section 41 the packet queued at the head of the flow selected by the flow selection section 43, and outputs the packet to the external communication network.

5           Next, descriptions will be given of operations of the output queue section 4 with reference to FIG. 4. FIG. 4 is a flowchart for describing an example of operations in the output queue section according to the invention. When a packet of the flow *i* is provided from the polishing section  
10   3, the buffer section 41 stores the packet (Step S401). Then, arrival order and output order of packets are managed so that packet order is not reversed and a succeeding packet is not output first. For example, as shown in FIG. 1, a FIFO buffer is provided for each flow and a packet belonging to the same  
15   flow is stored at the rearmost position of the same FIFO buffer, and thereby it becomes possible to make management so that a firstly arrived packet is output first in terms of the same flow.

          Further, class setting information is also provided  
20   from the polishing section 3 to the output queue section 4. When the class setting information for the flow *i* is provided, the schedule storage section 42 stores the flow identification information for identifying the flow *i* by class according to information showing the class in the class  
25   setting information (Step S402).

Specific descriptions will be hereinafter given of the process of the foregoing Step S402. For example, as shown in FIG. 1, when the number of classified classes is three classes of top priority class, priority class, and best effort class, in the class setting information provided from the polishing section 3, at least flow identification information for identifying the flow, to which a packet belongs, and the class set for that flow (one class of the foregoing top priority class, priority class, and best effort class) are described. Further, in the schedule storage section 42, FIFO buffers for respective classes (for example, when three classes exist, three FIFO buffers) are provided, and flow identification information belonging to the same class is stored at the rearmost position of the same FIFO buffer. Thereby, it becomes possible to make management so that firstly arrived flow identification information is output first in terms of the same class.

Next, the flow selection section 43 selects the flow to be output next with reference to the information stored in the schedule storage section 42. Specifically, when flow identification information exists in the FIFO buffer of the top priority class in the schedule storage section 42 (in the case of "YES" in Step S403), the flow selection section 43 selects the flow identification information at the head of the FIFO buffer of the top priority class (① of FIG. 1),

and obtains the flow identification information as output flow identification information for identifying the flow to be output next (Step S405).

Further, when flow identification information does  
5 not exist in the FIFO buffer of the top priority class in the schedule storage section 42 (in the case of "NO" in Step S403), and flow identification information exists in the FIFO buffer of the priority class, the class one grade lower than the top priority class (in the case of "YES" in Step  
10 S404), the flow selection section 43 selects flow identification information at the head of the FIFO buffer of the priority class (② of FIG. 1), and obtains the flow identification information as output flow identification information for identifying the flow to be output next (Step  
15 S406).

Further, when flow identification information does not exist in the FIFO buffer of the priority class of the schedule storage section 42 (in the case of "NO" in Step S404), the flow selection section 43 selects flow identification  
20 information at the head of the FIFO buffer of the best effort class, the class one grade lower than the priority class (③ of FIG. 1), and obtains the flow identification information as output flow identification information for identifying the flow to be output next (Step S407). When flow  
25 identification information does not exist in the FIFO buffer

of the best effort class either, determination is made that packets to be output do not exist, and no packet is output.

By one process of the foregoing Steps S405 to S407, the flow selection section 43, which has obtained the output  
5 flow identification information showing the flow to be output provides output flow notification information for requesting the packet output section 44 to output a packet from the flow to be output (Step S408). The packet output section 44 selects the packet existing at the head of the  
10 FIFO buffer of the flow to be output with reference to the output flow identification information, and outputs the packet to the external output line (Step S409).

In this embodiment, the method, in which the polishing section 3 compares the packet arrival rate per a given time  
15 to the band setting value is implemented. However, this method is not only way to go, but it is possible to use other method such as observing input quantity for every flow by performing polishing by using token bucket method.

As described above, according to the first embodiment  
20 of the invention, a flow, to which an input packet belongs is identified, class setting of the packet is performed with reference to band information for the flow and the like, the flow set to the highest class is sequentially selected, and the packets belonging to the flow are sequentially output.  
25 Thereby, band control, and at the same time, priority control,

in which classification is performed in units of packet according to band information of each flow, and the flow belonging to the class of higher priority is selectively output in units of packet become possible.

5 <Second embodiment>

Next, a second embodiment of the packet transfer control method and the packet transfer control circuit of the invention will be described. FIG. 5 is a block diagram showing a construction example of a packet transfer  
10 controller in the second embodiment of the invention. The packet transfer controller shown in FIG. 5 is a packet transfer controller, in which a band control function for every group is further added to the packet transfer controller shown in FIG. 1. Specifically, in the packet  
15 transfer controller shown in FIG. 5, a group setting information storage section 5 for storing information for each group (group setting information) is further provided. Further, in a rate calculation section 52 and a band comparative determination section 53, functions for  
20 performing processes about a packet arrival rate for every group (in some cases, hereinafter simply referred to as GPAR: Group Packet Arrival Rate) or upper limit band information for every group (in some cases, hereinafter simply referred to as GPPR: Group Peak Packet Rate) are added.

25 First, descriptions will be given of the group setting

information storage section 5. The group setting information storage section 5 stores flow/group correspondence information showing to which group each flow belongs and information for each group (group setting information). When flow identification information is notified from the flow identification section 1, the group setting information storage section 5 specifies the group with reference to the flow/group correspondence information, and sends the group setting information for the group specified by the flow identification information to the polishing section 3.

FIG. 6 is a view showing a model of an example of the flow/group correspondence information stored in the group setting information storage section according to the second embodiment of the invention. FIG. 7 is a view showing a model of an example of the group setting information stored in the group setting information storage section according to the second embodiment of the invention.

In the flow/group correspondence information shown in FIG. 6, correspondence relation between each group 1 to  $m$  ( $m$  is an integer number of 1 or more, and the number of types of groups to be identified) and each flow 1 to  $n$  ( $n$  is an integer number of 1 or more, and the number of types of flows to be identified) are described. For example, in the example shown in FIG. 6, it is found that flows 1 to 5 belong to group

1, and flows 6 to 10 belong to group 2. As in setting flows, types and the number of groups, correspondence between flows and groups and the like can be voluntarily set according to needs. For example, a plurality of flows belonging to the  
5 same link or the same VPN (Virtual Private Network) can be respectively grouped.

Further, the group setting information shown in FIG. 7 has upper limit band information GPPR1 to GPPRm of each group 1 to m and packet arrival rate information GPAR1 to  
10 GPARm of each group 1 to m. Of the group setting information, regarding an entry of the upper limit band information GPPR, a setting value is previously stored for each group; and regarding an entry of the packet arrival rate information GPAR, a stored value is sequentially updated according to  
15 results of input monitoring of the packet by the polishing section 3.

The group setting information storage section 5 receives the flow identification information from the flow identification section 1. Then, first, the group setting  
20 information storage section 5 refers to the foregoing flow/group correspondence information and determines the group, to which the input packet belongs. Further, the group setting information storage section 5 refers to the group setting information to obtain the group setting information  
25 set for the determined group, and notifies the group setting

information of the group to the polishing section 3. In addition to the aspect that the group setting information storage section 5 notifies the group setting information of the group identified by the flow identification information to the polishing section 3, for example, it is possible to adopt an aspect that flow identification information is notified from the flow identification section 1 to the polishing section 3, and the polishing section 3 refers to flow/group correspondence information and group setting information to read out the group setting information for the desired group.

Next, descriptions will be given of operations of the polishing section 3 with reference to FIG. 8. FIG. 8 is a flowchart for describing an example of operations in the polishing section according to the second embodiment of the invention. For example, when a packet of a flow *i* arrives at the polishing section 3, first, the rate measurement section 31 measures the arrival rate of the packet (Step S801). The measured arrival rate of the packet is notified from the rate measurement section 31 to the rate calculation section 52.

Further, the rate calculation section 52 obtains the flow setting information for the flow *i*, to which the packet belongs from the flow setting information storage section 2. Further, the rate calculation section 52 obtains the



group setting information for a group  $j$ , to which the flow  $i$  of the packet belongs from the group setting information storage section 5 (Step S802). Here, the flow  $i$  shall belong to the group  $j$ .

5           The rate calculation section 52 newly calculates packet arrival rate information  $PAR_i$  of the flow  $i$  based on the measurement result of the rate measurement section 31 and the packet arrival rate information  $PAR_i$  in the flow setting information. Further, the rate calculation section  
 10   52 newly calculates packet arrival rate information  $GPAR_j$  of the group  $j$  based on the measurement result of the rate measurement section 31 and the packet arrival rate information  $GPAR_j$  in the group setting information (Step S803). As a calculation method for the packet arrival rate  
 15   information  $GPAR_j$ , the same method as the above-mentioned calculation method for the packet arrival rate  $PAR_i$  can be used.

Next, the band comparative determination section 53 compares the  $GPAR_j$  calculated in the rate calculation  
 20   section 52 to the upper limit band information  $GPPR_j$  in the group setting information (Step S804). For example, validation is made whether  $GPAR_j$  belongs to the following  
 (1)  $GPAR_j \leq GPPR_j$  or (2)  $GPAR_j < GPPR_j$ .

(1)  $GPAR_j \leq GPPR_j$  (in the case of "YES" in Step S804)

25           It is regarded that the arrived packet has not reached

the upper limit band information GPPR<sub>j</sub> set for the group *j* and is within the upper limit band set for the whole group *j*. That is, the packet does not violate the band set for the whole group *j*, and is allowed in view of the band set  
5 for the whole group *j*. For this packet, processes based on the flow setting information (Step S805: processes of Steps S304 to S309 in the portion surrounded by a dotted line in FIG. 3) are performed. Further, the band comparative determination section 53 uploads the packet rate information  
10 GPAR<sub>j</sub> in the group setting information of the group *j* stored in the group setting information storage section 5 by a new packet rate information GPAR<sub>j</sub> (GPAR<sub>j</sub> calculated in the rate calculation section 52) (S807).

(2) GPAR<sub>j</sub>>GPPR<sub>j</sub> (in the case of "NO" in Step S804)

15       Regarding the arrived packet, it is regarded that the upper limit band GPPR<sub>j</sub> previously set for the group *j* is outreached, and all the allowed excess band is used up. That packet is provided with disposition process (Step S806). In this case, the band comparative determination section 53  
20 notifies disposition request information for requesting disposition process of the packet to the packet disposition section 34. The packet disposition section 34 receiving the disposition request information performs disposition process of the packet. As in the first embodiment, for the  
25 purpose of effective use of band of the output link, it is

possible to allow the packet to be output if there is still excess band even after the upper limit band is outreached.

Except for the case that the foregoing process is performed in the polishing section 3 and disposition process of the packet is performed, the packet and the class setting information of the packet are provided from the polishing section 3 to the output queue section 4. The output queue section 4 receives such information and performs the same process as in the first embodiment. Thereby, the packet is selectively output.

In this embodiment, a plurality of flows are grouped to set a bunch of groups. Further, it is possible to group a plurality of groups belonging to the bunch of groups, construct groups in a hierarchical fashion, and perform band control process. Further, it is possible to group a plurality of flows by different aspects (different classification methods) to set a plurality of bunches of groups, and perform band control process in parallel in each bunch of groups.

As described above, according to the second embodiment of the invention, by setting flows and groups and identifying the flow and the group, to which the input packet belongs, it becomes possible to simultaneously perform band control for each group set for each flow, in addition to band control and priority control for every flow.

In the first and the second embodiments, flows are classified in three classes, top priority class, priority class, and best effort class. However, it is possible to change the number of classes depending on the assumed system,  
5 and possible to voluntarily set the number of classes without departing from the characteristics and the object of the invention. Further, types of flows or groups, the numbers of flows or groups can be voluntarily set according to needs.

Further, when packets of the flow determined as top  
10 priority class are continuously input, output of packets belonging to the flow of relatively lower classes may be delayed. Therefore, for example, it is preferable that values in the flow setting information and the group setting information are set and the network is constructed so that  
15 the total of band guarantee of top-priority class is smaller than a band of output link.

#### INDUSTRIAL APPLICABILITY

As described above, according to the invention, the  
20 flow, to which a provided packet belongs is identified, flow setting information for the identified flow is read out from previously set information, an arrival rate of the packet is measured, and an arrival rate for the flow, to which the packet belongs is calculated based on the arrival rate of  
25 the packet, class setting of the flow, to which the packet

belongs is performed in units of packet by comparing the arrival rate for the flow to the read flow setting information, and output order of a plurality of packets is controlled based on the class of the class-set flow, to which the packet  
5 belongs. Therefore, band control and priority control of packet output, in which class setting for each flow is performed according to the band that each flow uses, and packets belonging to each flow are output based on this set class can be realized by a simple hardware configuration.